REMARKS

Claims 7-13 are pending. Claim 7 has been amended.

Claim 7 stands objected to due to two minor informalities. Claim 7 has been revised to address the Examiner's concerns. Therefore, the objection to claim 7 should be withdrawn.

Claim 7 stands rejected under 35 U.S.C. § 103(a) as being unpatentable over Kamide (U.S. Patent No. 5,306,379) ("Kamide") in view of Kuo et al. (U.S. Patent No. 6,246,175) ("Kuo") in further view of Kamarehi et al. (U.S. Patent No. 5,961,851) ("Kamarehi") in yet further view of Dandl (U.S. Patent No. 5,975, 014) ("Dandl"). The rejection is respectfully traversed.

Kaminide discloses rectangular shared coils 18a, 18b wound around a rectangular shared chamber 31. This is similar in shape to the present invention but is functionally different. The coil used in the present invention is designed to establish a magnetic field for electron cyclotron resonance (ECR). By contrast, the coil disclosed by Kaminide is used for plasma confinement.

The coils of the present invention generate electron cyclotron resonance by setting the microwave frequency and magnetic field strength to particular values (e.g., 875 Gauss at 2.45 GHz). The coils generate a magnetic field which repels electrons by diamagnetism. Positively charged ions are transferred to reduce the gradient of a plasma potential generated by the transfer of electrons, thereby establishing a plasma flow of electrons and ions. The magnetic field generated by the coils of the present invention is in a direction perpendicular to the plasma flow.

The magnetic field of Kamide, by contrast, is not for generating an electron cyclotron resonance or for generating a plasma flow. Rather, the coils 18a, 18b of Kamide confine plasma to generate a magnetic field for generating a high density plasma bar 84. (Col. 3, Lines 63-67) Claim 7 has been amended to more clearly recite these substantial differences between the Kamide and the claimed invention.

The plasma generating chamber and rectangular shape of the coils are an important aspect of the present invention. The rectangular shape of the coils solves the problem of a device becoming large and expensive by the coil enlarged to obtain magnetic field strength for generating ECR by enlargement of the size without changing the circular shape which was a problem for prior art large area substrate of ECR plasma processing devices, such as that disclosed by Kamide. In addition, enlargement of the coil by maintaining the conventional circular shape requires large coils to obtain the necessary magnetic field strength and, thus, space constraints may prevent the desired ECR plasma flow from being obtained. The present invention resolves these problems through the rectangular shape of the coils.

The Examiner regards the surface wave resonant cavity disclosed by Kuo as the "cavity resonator" recited in claim 7 with one terminal end portion closed (i.e., having no opening) with a metal plate and another end having a slit. The Examiner is correct to indicate that Kuo's surface wave resonant cavity is a cavity resonator provided at the end of a waveguide and that it has similar end portions as the claimed invention. However, between Kuo and the claimed invention, the resonating microwaves are different, and the resonators themselves have a different configuration and function.

The cavity resonator of the present invention is provided in the waveguide to introduce microwaves from the microwave transmitting means to the plasma generating chamber. According to the present invention, a cavity resonator is constructed by forming a slit (e.g., an opening 38) in the waveguide. A plurality of openings 34 are located in the side of the cavity resonator at an interval corresponding to the guide wavelength λg, thereby introducing in-phrase microwaves into the plasma generating chamber.

Kuo, by contrast, discloses a surface wave resonant cavity 100 provided at the end of a waveguide tube 80. The surface wave resonant cavity 100 and the waveguide tube 80 are of a very different shape than those of the present invention. In addition, the surface wave resonant cavity 100 does not resonate with a standing wave in the waveguide tube but rather with a surface wave

generated at the surface of a dielectric provided at the boundaries with a plasma generating chamber. Therefore, the period L of vertical vanes 20 and interval strips 30 cannot be made to measure one-half of the microwave guide wavelength (i.e., $\lambda g/2$), as recited in claim 7.

Microwaves propagate similarly in the microwave inducing portion 30 and the cavity resonator of the present invention. By contrast, the role of the vertical vanes 20 and the interval strips 30 disclosed by Kuo appears to be to propagate electromagnetic field energy in the surface wave induced in a dielectric surface by locating the end of the vertical vanes 20 in proximity to a dielectric to induce a microwave electromagnetic field adjacent to the end of the vertical vanes 20 in the dielectric. According to Kuo, microwaves resonate in the waveguide tube 80 and the surface wave resonant cavity 100, each of which have very different sectional shapes. Thus, the resonator of the present invention has a different configuration and function than the resonator disclosed by Kuo.

Kamarehi discloses a structure with irises 52, 54, 56, 58 provided at the side of a microwave enclosure 42, which is partitioned by partitions 44, 45, 46. Thus, the regions defined by partitions 44, 45, 46 are similar to the resonance units of the present invention. According to Kamarehi, microwave energy propagates from a Magnetron 60 to a waveguide section 66 through irises 52, 54, 56, 58 into a microwave enclosure 42 and a plasma tube 40. In other words, the microwave energy is channeled from the Magnetron 60 to the plasma tube 40.

In order to analogize the structure of partitions 44, 45, 46 of Kamarehi to the present invention, the resonance unit of the present invention would have to be provided in the microwave transmission portion 35. However, the resonance unit of the present invention is not provided in the microwave transmission portion 35 but rather between the microwave introducing portion 30 and the microwave transmission portion 35. (FIG. 1B) In other words, the resonance unit of the present invention is provided at a different position than the partitions disclosed by Kamarehi.

Also, if Kamarehi were analogous to the present invention, then the partitions 44, 45, 46 would be located in the waveguide section 66. However, as noted above, the partitions 44, 45, 46 are not located in the waveguide section 66 but rather within microwave enclosure 42. Thus, the partitions disclosed by Kamarehi are different than the resonance unit of the present invention. Claim 7 has been amended to more clearly distinguish over Kamarehi.

As the Examiner correctly indicates, Dandl discloses that in-phase microwaves can be extracted from an opening 63B and stubs 62T formed at λg/2 intervals. (FIGS. 8A and 8B) This occurs when a magnetic field H2 is generated on a surface in the direction shown in FIG. 8B, where stubs 62T are formed in an outer conductor 64 of the coaxial transmission line 66 at the time of TEM mode microwave propagation to the coaxial transmission line 66. (Col. 10, Line 50) In this configuration, the fact that an in-phase magnetic field generates at the position of the stubs 62T spaced at λg/2 intervals linearly in alternating polarity is known to those skilled in the art.

Dandl discloses a method for extracting in-phase microwaves from a waveguide. However, the present invention is directed not only to extracting in-phase microwaves from a waveguide but also to generating a highly dense ECR plasma uniformly in a wide range. This cannot be accomplished by the prior art.

As described in Applicant's specification, an object of the present invention is to provide an ECR plasma device that can sputter or etch even a large-size rectangular sample, such as a flat panel display ("FPD"). A highly dense ECR plasma is required for sputtering or etching treatment. Uniformity is required for treatment of large-size samples. Conventionally, a highly dense ECR plasma could not be generated with a high uniformity and, therefore, ECR plasma could not be applied to FPD manufacturing processes.

The tasks to be solved to obtain high uniformity and high density ECR plasma are: (1) to introduce a high power microwave with high uniformity to a large area and (2) to provide a strong magnetic field required for the ECR and a diverging magnetic field for establishing an ECR plasma

flow to a large area. The present invention allows both of these tasks to be accomplished at the same time.

The method for transmitting the high power microwave to a plasma generating chamber in task (1) is to use a hollow waveguide and the microwave transmission portion 35 provided so as not to introduce microwaves directly from the opening 34 to the plasma generating chamber. It is well known to those skilled in the art that the use of coaxial transmission lines, as in Dandl, requires spacers to prevent transmission of high power microwaves with high frequency. Spacers, however, absorb microwaves and generate heat. In an exemplary embodiment of the present invention, microwave power of 2000-3000 W is used with a microwave frequency of 2.45 GHz and the longitudinal length of the rectangular shape is 60 cm. The transmission of such microwaves in a coaxial line, such as disclosed by Dandl, is dangerous due to heat generation.

Moreover, according to Dandl, there is a wide opening directed directly to the plasma generating chamber. This exponentially decreases the magnetic field strength of the microwaves radiated from the opening, as it well known to those skilled in the art of antenna theory, and prevents high power microwaves from being transmitted to the plasma generating chamber. The present invention, by contrast, provides a microwave transmission portion 35 at the end of the opening 34, which allows high power microwaves to propagate to the plasma generating chamber.

In addition, the present invention provides that approximately planar microwaves are transmitted to the microwave transmission portion 35 through a plurality of openings 34. As a result, generation of a standing wave in a longitudinal direction of the plasma generation chamber can be reduced and high uniformity in the plasma can be achieved. This is very different than the technical idea disclosed by Kamarehi, which generates microwaves in TM110 and TM010 mode in a microwave enclosure 42 partitioned by partitions 44, 45, 46. (Col. 1, Lines 48-52) In other words, Kamarehi does not teach or suggest arranging microwaves in a partitioned area by partitions in their phases.

To achieve task (2) and provide the strong magnetic field required for ECR to the plasma generation chamber, the present invention adopts a plasma generating chamber with a rectangular section. This allows the required strong magnetic field to be generated in the plasma generating chamber without largely increasing the number of turns or current values.

Further, a rectangular-shaped plasma chamber is consistent in shape with the microwave introducing portions (resonance units 32, 33, and microwave transmission portion 35). This allows high-power in-phase microwaves to be introduced into the plasma generating chamber and also allows generation of ECR plasma with high density and uniformity, as required to process large area substrates with a magnetic field generating device (coil) of practical size. This combination of features provides advantages not obtainable with the prior art and not taught or suggested by any of the cited references, whether taken alone or in combination.

Claim 7 has been amended to more clearly recite the differences between the claimed invention and the cited prior art. For at least all of these reasons, the rejection of claim 7 should be withdrawn and the claim allowed.

Claims 8, 9, and 11 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Kamide in view of Kuo in further view of Kamarehi in yet further view of Dandl in still further view of Kiroshi et al. (U.S. Patent No. 5,389,154) ("Kiroshi"). The rejection is respectfully traversed.

Claim 8 recites an "ECR plasma source" wherein "wherein the microwave introducing means includes microwave branching means...." Claim 9 recites an "ECR plasma apparatus comprising the ECR plasma source as claimed in claim 8."

The Examiner correctly concludes that the Kamide, Kuo, Kamarehi, and Dandl combination does not teach or suggest "microwave introducing means includes microwave branching means," as recited in claims 8 and 9. (Page 8) Therefore, the Examiner relies on Kamide, Kuo, Kamarehi, and

Dandl in further combination with Kiroshi. However, as noted above, the Kamide, Kuo, Kamarehi, and Dandl combination fails to teach or suggest other limitations of claim 7, from which claims 8 and 9 depend. Kiroshi does not cure the failings of the Kamide, Kuo, Kamarehi, and Dandl combination. Therefore, the rejection of claims 8 and 9 should be withdrawn and the claims allowed.

Claim 11 does not recite "microwave introducing means includes microwave branching means," so Applicants assume claim 11 is rejected over the Kamide, Kuo, Kamarehi, Dandl, and Kiroshi combination in error. In any event, claim 11 depends from claim 7 and is allowable over the cited prior art for at least the reasons stated above with respect to claim 7 and on its own merits. Therefore, the rejection of claim 11 should be withdrawn and the claim allowed.

Claims 10 and 12 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Kamide in view of Kuo in further view of Kamarehi in yet further view of Dandl in still further view of Dotter et al. (U.S. Patent No. 6,463,874) ("Dotter"). The rejection is respectfully traversed.

Claims 10 and 12 recite an "ECR plasma apparatus … comprising sample moving means…."

The Examiner correctly concludes that the Kamide, Kuo, Kamarehi, and Dandl combination does not teach or suggest "sample moving means," as recited in claims 10 and 12. (Page 8) Therefore, the Examiner relies on Kamide, Kuo, Kamarehi, and Dandl in further combination with Dotter. However, as noted above, the Kamide, Kuo, Kamarehi, and Dandl combination fails to teach or suggest other limitations of claim 7, from which claims 10 and 12 depend. Dotter does not cure the failings of the Kamide, Kuo, Kamarehi, and Dandl combination. Therefore, the rejection of claims 10 and 12 should be withdrawn and the claims allowed.

Claim 13 stands rejected under 35 U.S.C. § 103(a) as being unpatentable over Kamide in view of Kuo in further view of Kamarehi in yet further view of Dandl in still further view of Goulouev (U.S. Patent No. 6,169,466) ("Goulouev"). The rejection is respectfully traversed.

Claim 13 recites an "ECR plasma source ... wherein an opening is formed between the first resonance unit and the second resonance unit."

The Examiner correctly concludes that the Kamide, Kuo, Kamarehi, and Dandl combination does not teach or suggest "an opening ... formed between the first resonance unit and the second resonance unit," as recited in claim 13. (Page 9) Therefore, the Examiner relies on Kamide, Kuo, Kamarehi, and Dandl in further combination with Goulouev. However, as noted above, the Kamide, Kuo, Kamarehi, and Dandl combination fails to teach or suggest other limitations of claim 7, from which claim 13 depends. Goulouev does not cure the failings of the Kamide, Kuo, Kamarehi, and Dandl combination. Therefore, the rejection of claim 13 should be withdrawn and the claim allowed.

In view of the above, Applicants believe the pending application is in condition for allowance and respectfully request that it be passed to issue.

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Respectfully submitted,

By [signature]

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